2.4 Hazardous Waste Management:

Hazardous waste is any waste material that, when improperly handled, can cause substantial harm to human health and safety or to the environment. Hazardous wastes can take the form of solids, liquids, sludge's, or contained gases, and they are generated primarily by chemical production, manufacturing, and other industrial activities. They may cause damage during inadequate storage, transportation, treatment, or disposal operations. Improper waste storage or disposal frequently contaminates surface and groundwater supplies. People living in homes built near old and abandoned waste disposal sites may be in a particularly vulnerable position. In an effort to remedy existing problems and to prevent future harm from hazardous wastes, governments closely regulate the practice of hazardous-waste management.

2.4.1 Hazardous Waste Characteristics:

Hazardous wastes are classified on the basis of their biological, chemical, and physical properties. These properties generate materials that are either, toxic, reactive, ignitable, corrosive, infectious, or radioactive. Toxic wastes are poisons, even in very small or trace amounts. They may have acute effects, causing death or violent illness, or they may have chronic effects, slowly causing irreparable harm. Some are carcinogenic, causing cancer after many years of exposure. Others are mutagenic, causing major biological changes in the offspring of exposed humans and wildlife. Reactive wastes are chemically unstable and react violently with air or water. They cause explosions or form toxic vapors. Ignitable wastes burn at relatively low temperatures and may cause an immediate fire hazard. Corrosive wastes include strong acidic or alkaline substances. They destroy solid material and living tissue upon contact, by chemical reaction. Infectious wastes include used bandages, hypodermic needles, and other materials from hospitals or biological research facilities. Radioactive wastes emit ionizing energy that can harm living organisms. Because some radioactive materials can persist in the environment for many thousands of years before fully decaying, there is much concern over the control of these wastes. However, the handling and disposal of radioactive material is not a responsibility of local municipal government. Owing to the scope and complexity of the problem, the management of radioactive waste (particularly nuclear fission waste) is usually considered to be a separate engineering task from other forms of hazardous-waste management and is discussed separately. The primary constituents of waste streams from explosives manufacturing operations that result in liquid and soil contamination are nitroaromatics and nitramines including:

Explosives Waste Constituents

#	Acronym Compound Name:
1	TNT 2,4,6-trinitrotoluene.
2	RDX Hexahydro-1,3,5-trinitro-1,3,5-triazine.
3	HMX Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
4	Tetryl Methyl-2,4,6-trinitrophenylnitramine.
5	Picric Acid 2,4,6-trinitrophenol.
6	PETN Pentaerythritol tetranitrate.
7	TATB Triaminotrinitrobenzene.

The most frequently occurring impurities and degradation products from these include:

Explosives Waste Degradation Products

#	Acronym Compound Name:
1	2,4-DNT 2,4-dinitrotoluene.
2	2,6-DNT 2,6-dinitrotoluene.
3	2A-4,6-DNT 2-amino-4,6-dinitrotoluene.
4	4A-2,6-DNT 4-amino-2,6-dinitrotoluene.
5	TNB 1,3,5-trinitrobenzene.
6	DNB 1,3-dinitrobenzene.
7	NB Nitrobenzene.
8	Picramic Acid 2-amino-4,6-dinitrophenol.

Bioaugmentation Treatment Materials:

Table 15: Bioaugmentation Treatment Materials

Pharmaceuticals	Spent Fermentation Media, Tabletzing Binders and Solvents
Refinery Wastes	Phenols, ammonia, hydrogen sulfide, oils and greases
Steel Manufacturing	Phenols, cyanide, thiocyanate, ammonia and rolling oils
Tanneries	Vegetable tanning waste
Textiles	Surfactants, starches and organic dyes used in textile mills
Alcohols	Sugars, tannins and alcohols
Beverages	Liquid sugars, high fructose corn syrup and flavorings
Dairy	Fats and whey
Confectionery	Sugar waste and chemicals
Halogenated Aromatics	Chloro and di-chloro phenol
Detergent	Surfactants and other components of detergents
Petrochemicals	Petroleum hydrocarbons, straight and branched alkanes, BTX
Paper/Cellulose	BOD reduction and odor control

A study was carried out by myself in summer of 2005 for the Pakistan Ordnance Factories (POF) to present an Action Plan for remediation of hazardous effluent from their Explosives Factory. It was realized that in order to arrive at a precise and dynamic Action Plan the following steps had to be undertaken.

3-Tier Approach.

a)

Preliminary Process Selection, Bio–Treatability Testing and Price Estimation.

a. Review all prior written studies, analysis and site work.
Brief Review and Professional Appraisal carried out.
b. Implement Bio-feasibility screening and Data Interpretation.
Carried out.

b) Bio-treatability Studies and Process Confirmation.
a. Laboratory Studies.
b. In Situ, Ex Situ (water, slurry).
Remedial Design/ Remedial Action(RD/RA) for:
In-Situ Pilot Scale Treatability Test Of Municipal Liquid/Solid Waste.
Phase 1:
Biodegradation of the Municipal Liquid Treatment Effluents (Aerobic,Anaerobic and Facultative).
Phase 2:
Biodegradation of Municipal Solid Waste through Anaerobic Composting with Bioaugmentation.
a. In Situ, Ex Situ (water, slurry).
Remedial Design/ Remedial Action(RD/RA) for:
In-Situ Pilot Scale Treatability Test Of Hazardous Liquid/Solid Waste.
Phase 3:
Biodegradation of Hazardous Liquid Waste through Bio-oxidation and Phytoremediation.
Phase 4:
Biodegradation of Hazardous Liquid Waste through Anaerobic Slurry Decomposition with Bioaugmentation.
Bioenvironmental Action Plan:
Remedial Design/ Remedial Action (RD/RA) for:
In-Situ
Pilot Scale Treatability Test of Liquid/ Solid Waste Bio/ Phytoremediation of:
1: Mixture of Mono, Di and Tri-Nitro Toulene, Tetryl and Nitrocellulose, HazardousLiquid Waste.
2: Municipal Liquid Waste.
3: Hazardous Solid Waste.
4: Municipal Solid Waste.

:**Proposed Bioremediation Process**

Phase	ITEM
Phase 1	Biodegradation of Municipal Liquid Waste
Phase 2	Biodegradation of Municipal Solid Waste
Phase 3	Bio-oxidation of Hazardous Liquid Waste
Phase 4	Phytoremediation of Hazardous Liquid Waste
Phase 5	Anaerobic Biodegradation of Hazardous Liquid Waste

Biological treatment or bioremediation is a developing technology that uses microorganisms to degrade organic contaminants into less harmful compounds. Phytoremediation uses plants to degrade and uptake organic and inorganic contaminants. They are practical and inexpensive alternatives to traditional methods such as incineration, which often produce toxic secondary wastes or simply lowering of pH.
The sites this report addresses are potential sites for these types of bio/ phytoremediation.

Our goal was to treat the Municipal Liquid Waste site is to use bioremediation as the primary treatment and anaerobic slurry decomposition as secondary treatment.
Municipal biodegradable Solid Waste was to be composted anaerobically along with bioaugmentation.
For the Hazardous Liquid Waste, bio-oxidation as primary and Phytoremediation or anaerobic slurry decomposition as secondary treatments was proposed.
Our aim was to reduce the hazardous properties of the target compounds through the process of bio and phytotransformation and offer as near complete return of the compounds into the normal geochemical carbon and nitrogen cycles through mineralization.

Sites Evaluation
Two Liquid and one Solid Waste Dump Sites were visited by the Bioenvironmental Management Consultant.
Solid Waste Dumping Ground consisted of Open Air Dumping of untreated and non-segregated Solid Waste.
As facilities for secondary segregation do not exist and are expensive to install, the Consultant recommended Primary Segregation (Segregation on the part of the polluting agency into Biodegradable and Non Degradable Streams. The Biodegradable Waste can then be effectively anaerobically composted, using Bioaugmentation. This method is extremely effective and rapid apart from being low-cost.

For Demonstration purposes as near primarily segregated biodegradable municipal solid waste was to be anaerobically composted along with bioaugmentation. Existing Municipal Liquid Waste Treatment Plant (British Era) with inflow of 4 times the rated capacity(50,000 population) has resulted in incomplete digestion and discontinuation of anaerobic decomposition in the facility that exists from over 100 years. It is possible to increase the efficiency of decomposition and thus make maximum use of existing facilities. This would entail bioaugmentation with a range of products to determine efficacy and adaptation to local conditions.

On successful treatment the products can be cultured locally either independently or as Joint Venture with the manufacturer.

Similarly, the anaerobic digester can be re-commissioned (subject to structural soundness).

Hazardous Liquid Waste Treatment is restricted to open air incineration, oxidation and regulation of pH to neutral value. At the exit point a combination of Hydraulic Ram for raising the Liquid Waste in order to access near by Bank of Dhamrah Kas for purposes of Phytoremediation trials will be required.

As capacity of adjoining area and rate of production of Liquid waste (4 cusecs) both do not match and also due to the requirement for demonstration for efficacy, a limited quantity of Liquid Waste was to be introduced to the Beds. Remainder effluent will rejoin its original watercourse after biooxidation/ deionization through the means of a created waterfall. This process will be replicated at the point where effluent subjected to phytoremediation rejoins the DhamrahKas.Along with these treatments, it was proposed to pipe a part of the effluent to the anaerobic digester situated in the Municipal Liquid waste Treatment Plant. This would serve to show anaerobic decomposition as a demonstration for evaluation purposes. Thus the Sites would be subjected to the following:

Bioaugmentation: Phytoremediation: Bio-Oxidation: Anaerobic Bioslurry/ Composting:

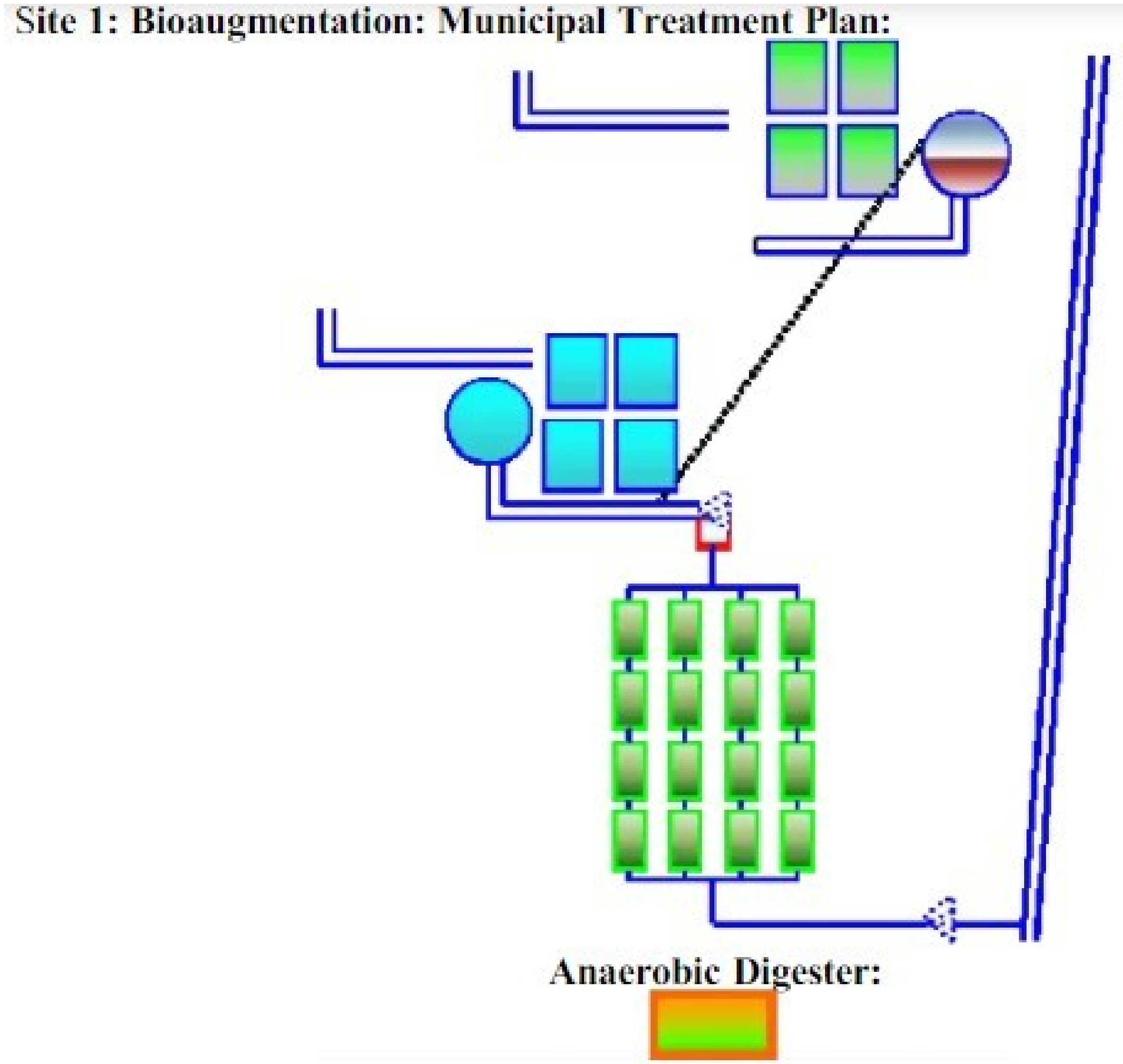

Figure 6 Treatment Perspective

Site 2: Composting: Anaerobic
Bioaugmentation:
Hazardous Liquid Waste Pre-Treatment Plant:
Phase D: Anaerobic Decomposition of Hazardous Waste:
Site 3:Phase A: Hydraulic Ram.
Phase B: Waterfall Oxidation/ Deionization.
Phase C: "Reed Beds".
Site 4: Waterfall Oxidation/ Deionization.

Compounds Proposed for Degradation

#	Compounds to be Degraded:
1	Mono, Di and Tri-Nitro Toluene
2	Nitrocellulose (cellulose nitrate)
3	Tetryl
4	Sulfate
5	Oil & Grease
6	Sulphide
7	Chlorine
8	Chloride
9	Lead
10	Iron
11	Cadmium
12	Chromium
13	Nitrocellulose (cellulose nitrate)

Phase 1. Biodegradation of the Municipal Liquid Treatment Effluents (Aerobic, Anaerobic and Facultative).

Phase 2. Biodegradation of Municipal Solid Waste through Anaerobic Composting with Bioaugmentation.

Phase 3. Biodegradation of Hazardous Liquid Waste through Bio-oxidation and Phytoremediation.

Phase 4. Biodegradation of Hazardous Liquid Waste through Anaerobic Slurry Decomposition with Bioaugmentation. Application and Sampling Methods:

Initially, sampling the site will involve samples from monitoring points placed around the site.
Sampling should be conducted to determine contaminant as well as nutrient levels in the effluents.
Sampling of the water would also be important.
Information on the nutrient levels is important so that possible growth rates can be established.

Foreseeable Problems:
The problems that can occur during the bioremediation of these explosive compounds could arise from the bacteria and fungi unable to adapt to the extreme anaerobic or anaerobic environment for example the anaerobic fungi isolated from the rumen might not tolerate the conditions given. Due to the assumption made, that this fungi will be able to degrade nitrocellulose in an ideal laboratories conditions may not necessarily mimic the activities in the environment.

Other microorganisms, like the de-nitrifiers, which grow relatively fast, might use up the entire available nitrate and inhibit their own growth. Furthermore, the assumption that the ammonium ions and nitrate ions are in equilibrium might not hold due to an influx of microbial activities, which might inhibit denitrification. This inhibition of denitrification may occur due to temperature increase in the summer, nutrient levels too low or too abundant.

Problems that might occur during Biodegradation, or might already be occurring include the release of nitric oxide, nitrous oxide and nitrogen dioxide into the environment.

This needs to be monitored, as both nitrogen dioxide and nitric oxide are toxic to humans and to many other organisms. Nitrous oxide is able to diffuse up to the lower atmosphere and up to the stratosphere where it reacts with the ozone causing partial damage to the protective layer (Boyd, 1988).
UV penetration to the surface of the earth is further increased.

Imperative:
The Gross Pollution of our Surface waters is a cognizable Crime, yet this is being carried out on a large scale throughout Pakistan. Municipal; Industrial; Chemical and Hazardous Pollutants are being dumped openly with no regard for Human or Wildlife or the Environment. When pointed out, The Authorities have brazenly denied culpabaility.
Poisonous Gasses are polluting the Air we Breathe.
Our Groundwater is being poisoned and is mostly unfit for consumption.
Our Soils are Heavily Polluted and Biota have been ruthlessly killed.
We need to take Action NOW!

Costs:
The need for prevention of environmental contamination from hazardous wastes is overwhelming. The cost for remediation of these contamination sites all over Pakistanis estimated at over 50 Arab Rupees, and even at this cost most sites would not achieve 'Pristine' condition.

Most technologies currently considered for remediation are expensive and often do not effectively alleviate the pollution hazard.
Bio/Phytoremediation is usually much cheaper than other clean-up options, and provides great adaptability and tailorabilty to specific environments (Walker and Kaplan, 1992).

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